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Survey of Trace Elements in Fish and Shellfish landed at Scottish Ports 1975-76

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Introduction

The Working Party on the Monitoring of Foodstuffs for Heavy Metals was set up in 1971 by the Ministry of Agriculture, Fisheries and Food (MAFF), primarily to consider the occurrence of mercury in food, but it has also examined a range of other contaminants, notably lead and cadmium. As part of Department of Agriculture and Fisheries for Scotland (DAFS) surveillance of Scottish fisheries, and to provide data for this Working Party, an initial survey was made in 1971-72 of metals in Scottish fish and shellfish (Topping, 1973a, b). The results were presented and discussed in relation to other foodstuffs and probable dietary intake of metals in a series of publications (MAFF, 1971, 1972, 1973a, 1973b, 1975). In response to a request from this Working Party, a further, more extensive, survey was carried out in 1975-76. The purpose of this paper is to present in detail the results of this second survey, both as a completed study and as background to other, more specialised studies to be described elsewhere.

Materials and Methods

The purpose of the survey was to determine the concentrations of selected metals in the main fish and shellfish species consumed in the United Kingdom, with particular reference to public health. Samples were therefore collected and processed under conditions that were considered similar to those likely to be encountered during commercial handling. Species in this report are referred to by common name; a key to specific names is given in Table I.

Materials

Samples of fish and shellfish were purchased on the fish market at selected Scottish ports (Tables II and III, Figure 1) during September-December 1975. In some cases the samples could be associated with particular fishing grounds and the sampling scheme was designed to reflect the general pattern of commercial landings at that time. Sampling covered 18 edible, commercially exploited fish species and eight shellfish species (including squid), all of which were obtained iced but not frozen. Each fish sample consisted of 10 individuals, but sample sizes for shellfish were more variable.

Sample preparation

Fish and squid were filleted and skinned using stainless steel knives. The fillets from each fish were thoroughly chopped and mixed, and a subsample of about 50g taken.

Crabs were sampled by dissection separately of the claw and body meat, and further samples of the commercial products white meat (claw muscle tissue) and brown meat (body tissue) were also obtained. Lobster claw and tail muscle were sampled separately, as were scallop muscle and gonad. Norway lobsters and queens were sampled as tails and adductor muscle respectively, and homogenates were made of 50-100 individuals of periwinkle (entire soft parts) and shrimps (tails). All prepared samples were stored deep-frozen until analysis.

Figure 1. Scottish fishing ports from which samples of commercial fish and shellfish landings were obtained.

Analysis

For the determination of lead, cadmium, copper and zinc, 10g samples were digested in silica flasks overnight at 100°C with 20 cm^3 analytical grade concentrated nitric acid. The next day, 2 cm^3 analytical grade perchloric acid was added, and the digest boiled down to 4-5 cm^3. After cooling, the digests were made up to 25 cm^3 with distilled water. The four metals were determined by flame atomic absorption spectrophotometry with detection limits of 0.1, 0.02, 0.02 and 0.1 $\mu g\ g^{-1}$ respectively.

Mercury was determined by a dry combustion-flameless atomic absorption technique described by Topping, Pirie, Graham and Shepherd (1975), with a detection limit of 0.01 $\mu g\ g^{-1}$. Arsenic was measured by a technique described by Shepherd and Topping (1977) with a detection limit of 0.2 $\mu g\ g^{-1}$. In total 720 fish and 177 shellfish samples were analysed.

All these methods have been successfully compared with methods used in other laboratories through intercomparison exercises organised by the International Council for the Exploration of the Sea (Topping and Holden, 1978).

Results

The analytical data are summarised by species in Tables IV and V, which present means, standard deviations, coefficients of variation, minima and maxima for each element. The results are further summarised in tables of

means and medians in Table VI. The complete data set is tabulated in Davies (1981), and is obtainable from the Marine Laboratory.

Lead

In the vast majority of samples lead was not detectable. No significance is given to occasional scattered positive values, although certain shellfish (eg queens and scallops) from the Clyde consistently contain measurable quantities of lead, and may therefore contain higher lead residues than many other commercial species.

Cadmium - Table VI, E

Cadmium concentrations in fin fish were below the detection limit of the analytical technique employed, although the element was regularly detectable in shellfish. Most striking results were obtained for cadmium in brown and body meat of crabs from the Orkney area, with a maximum level of 62.5 $\mu g\ g^{-1}$ (cf Topping, 1973b).

Copper - Table VI, A, F

In most fish, copper was found at about 0.1 - 0.4 $\mu g\ g^{-1}$, but lipid-rich pelagic fish (herring, mackerel and sprat) and the single dogfish sample contained more of this element (0.5 - 1.1 $\mu g\ g^{-1}$). As with cadmium, concentrations are 10 - 100 times higher in shellfish, particularly crabs, lobsters and periwinkles, and squid contained intermediate concentrations (mean 1.92 $\mu g\ g^{-1}$).

Zinc - Table VI, B, G

Like cadmium and copper, zinc is accumulated by a range of shellfish species, with highest concentrations being found in queens, scallops (gonads) and crabs. Levels in fish are about one tenth of these at 3 - 6 $\mu g\ g^{-1}$.

Mercury - Table VI, C, H

Mean mercury concentrations in fish and shellfish species were low (mainly less than 0.15 $\mu g\ g^{-1}$) and showed no systematic differences between species.

Arsenic - Table VI, D, I

Considerable differences in mean arsenic content between most round fish (ca 5 $\mu g\ g^{-1}$) and flatfish, particularly lemon sole, plaice and witch (up to 43 $\mu g\ g^{-1}$) were found. Notably high arsenic levels were found in plaice from Ling and Bergen Banks (Shepherd and Topping, 1977).

Discussion

The data in this report largely confirm the concentrations of copper, zinc, lead and cadmium in fish from Scottish waters reported by Topping (1973a).

Further comparison may be made between the metal concentrations found in Scottish fish landings (this survey) and those reported for fish landed at English and Welsh ports in 1974 (Murray, 1979). Results of the routine monitoring of five species carried out by MAFF (Burnham-on-Crouch Laboratory) are summarised in Table VII and compared with mean values for Scottish landings. It can be seen that the mean concentrations of mercury and copper are mainly higher in fish from England and Wales. There is a tendency for Scottish demersal species to contain more, and pelagic species less, zinc than reported by MAFF for the same species.

From the public health point of view, the levels of metals of primary concern (lead, cadmium, mercury) found in this survey are mainly low and confirm and supplement the results of the first survey, 1972. The survey was not designed to detect differences between species or areas, but rather to sample typical material presented for consumption. The levels of interpretation and comparison that can be made are therefore low, but indications of further useful investigations can be found. Topics worthy of further study include the distribution of cadmium in crabs and arsenic in flatfish. More generally, the sampling of fish in a more controlled manner, together with measurements of age, length, weight etc should allow more detailed

and thorough examination of the accumulation of metals, particularly mercury, in selected commercial species (eg halibut and dogfish (Topping and Graham, 1977, 1978)).

Summary Analyses of lead, cadmium, copper, zinc, mercury and arsenic in 26 species of edible fish and shellfish landed at Scottish ports in 1975-76 are presented. Concentrations of these elements are mainly low, below the statutory limits in force in certain countries for these substances in foodstuffs. The survey provides background information for further study of the accumulation of selected elements in marine foodstuffs, and highlights specific areas for research including cadmium in brown crab meat, and arsenic in plaice.

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Table I Common and Specific names of species analysed

Cod	*Gadus morhua*
Dab	*Limanda limanda*
Dogfish	*Squalus acanthias*
Haddock	*Melanogrammus aeglefinus*
Hake	*Merluccius merluccius*
Halibut	*Hippoglossus hippoglossus*
Herring	*Clupea harengus*
Lemon sole	*Microstomus kitt*
Ling	*Molva molva*
Mackerel	*Scomber scombrus*
Megrim	*Lepidorhombus whiffiagonis*
Monkfish	*Lophius piscatorius*
Plaice	*Pleuronectes platessa*
Saithe	*Pollachius virens*
Skate	*Raja naevus*
Sprat	*Sprattus sprattus*
Squid	*Loligo forbesii*
Whiting	*Merlangius merlangus*
Witch	*Glyptocephalus cynoglossus*
Crab	*Cancer pagurus*
Lobster	*Homarus vulgaris*
Norway lobster	*Nephrops norvegicus*
Periwinkle	*Littorina littorea*
Queen	*Chlamys opercularis*
Scallop	*Pecten maximus*
Shrimp	*Pandalus* sp.

Table II Fish samples obtained from Scottish ports

Port	Ayr	Mallaig	Ullapool	Stornoway	—	—	Anstruther	Aberdeen	Peterhead	Peterhead	Lossiemouth	Lerwick
Fishing area	Clyde	S Minch	N Minch	N Minch	Cape Wrath	Faroe	Forth		Bergen Bank	Ling Bank	Moray Firth	Shetland
Cod	√						√	√	√	√	√	√
Dab								√				
Dogfish								√				
Haddock	√						√	√	√	√	√	√
Hake	√											
Halibut								√				
Herring	√	√		√							√	√
Lemon sole								√				
Ling			√					√				
Mackerel	√	√			√		√	√	√		√	√
Megrim				√								
Monkfish	√		√			√		√			√	√
Plaice	√						√	√	√	√	√	√
Saithe	√						√	√	√	√	√	√
Skate								√				
Sprat	√						√				√	
Squid	√	√								√		
Whiting	√						√	√	√	√	√	√
Witch	√								√	√		

Table III Shellfish samples obtained from Scottish ports

Port	Ayr	Oban	Ullapool	Ullapool	Orkney	Orkney	—	Eyemouth	Pittenweem	Lerwick
Fishing area	Clyde	S Minch	N Minch	W coast	Scapa Flow	Papa Stour	Farne Deeps	Forth	Forth	Shetland
Crab — Claw				√ 3	√ 16			√ 10		
— Body				√ 3	√ 15			√ 10		
— White				√ 1		√ 22				
— Brown				√ 1		√ 2				
Lobster — Claw				√ 4	√ 5					
— Tail				√ 5	√ 5					
Norway lobster	√ 1	√ 10(1)	√ 10					√ (1)		
Perwinkle	√ 1								√ 1	
Queen	√ 8									
Scallop — Muscle	√ 10									√ 16
— Gonad	√ 10									√ 14
Shrimp							√ 1			

Table IV Summary of concentrations of metals ($\mu g\ g^{-1}$ wet weight) in fish landed at Scottish ports

Cod

	Pb	Cd	Cu	Zn	Hg	As
Ayr						
Mean	< 0.1	< 0.02	0.220	3.835	0.083	4.63
Std. Dev.			0.0627	0.4099	0.0368	5.2557
Coeff. var.			28.51	10.69	44.38	113.51
Min	< 0.1	< 0.02	0.14	3.19	0.04	0.7
Max	< 0.4	< 0.02	0.32	4.56	0.18	18.6
Forth						
Mean	< 0.1	< 0.02	0.354	4.503	0.155	2.09
Std. Dev.			0.2522	0.3553	0.0508	1.0279
Coeff. var.			71.24	7.89	32.79	49.18
Min	< 0.1	< 0.02	0.16	3.92	0.08	0.8
Max	< 0.1	< 0.02	1.05	4.97	0.24	4.6
Aberdeen						
Mean	< 0.1	< 0.02	0.243	4.450	0.109	-
Std. Dev.			0.0501	0.5475	0.0502	
Coeff. var.			20.626	12.304	46.06	
Min	< 0.1	< 0.02	0.16	3.38	0.07	
Max	< 0.1	< 0.02	0.30	5.24	0.24	
Bergen Bank						
Mean	< 0.1	< 0.02	0.231	3.956	0.039	1.39
Std. Dev.			0.0354	0.2661	0.0110	0.6008
Coeff. var.			15.332	6.727	28.22	43.22
Min	< 0.1	< 0.02	0.18	3.60	0.02	0.6
Max	< 0.1	< 0.02	0.29	4.32	0.06	2.4
Ling Bank						
Mean	< 0.1	< 0.02	0.292	4.426	0,48	1.65
Std. Dev.			0.0982	0.7282	0.0204	1.1385
Coeff. var.			33.624	16.453	42.58	69.00
Min	< 0.1	< 0.02	0.17	3.24	0.02	0.5
Max	< 0.1	< 0.02	0.53	5.29	0.08	4.3
Lossiemouth						
Mean	< 0.1	< 0.2	0.200	4.356	0.037	-
Std. Dev.			0.0467	0.5808	0,0134	
Coeff. var.			23.33	13.33	36.15	
Min	< 0.1	< 0.02	0.14	3.54	0.02	
Max	< 0.1	< 0.02	0.28	5.24	0.06	
Lerwick						
Mean	< 0.1	< 0.02	0.168	3.922	0.024	0.74
Std. Dev.			0.0305	0.5868	0,0084	0.4624
Coeff. var.			18.14	14.96	35.14	62.49
Min	< 0.1	< 0.02	0.12	2.99	0,01	0.4
Max	< 0,1	< 0.02	0.21	4.76	0,04	2.0

Dab

	Pb	Cd	Cu	Zn	Hg	As
Aberdeen						
Mean	< 0.1	< 0.02	0.179	5.252	0.104	4.53
Std Dev.			0.0764	0.8431	0.0710	2.6500
Coeff. var.			42.664	16.053	68.269	58.499
Min	< 0.1	< 0.02	0.07	4.49	0.04	2.5
Max	< 0.1	< 0.02	0.31	6.75	0.28	11.6

Dogfish

Aberdeen						
Mean	< 0.1	< 0.02	0.623	4.747	0.095	2.74
Std Dev.			0.2478	0.4591	0.0510	0.5211
Coeff. var.			39.781	9.671	53.684	19.018
Min	< 0.1	< 0.02	0.40	3.96	0.04	1.9
Max	< 0.1	< 0.02	1.21	5.33	0.20	3.8

Haddock

Ayr						
Mean	< 0.1	< 0.02	0.183	3.310	0.035	-
Std Dev.			0.0611	0.6183	0.0097	
Coeff. var			33.39	18.68	27.77	
Min	< 0.1	< 0.02	0.12	2.45	0.02	
Max	< 0.1	< 0.02	0.31	4.69	0.05	
Forth						
Mean	< 0.1	< 0.02	0.300	4.452	0.050	2.96
Std Dev.			0.0855	0.7949	0.0170	0.5985
Coeff. var.			28.50	17.85	33.99	20.22
Min	< 0.1	< 0.02	0.20	3.41	0.04	2.2
Max	< 0.1	< 0.02	0.46	6.21	0.08	4.1
Aberdeen						
Mean	< 0.1	< 0.02	0.197	4.092	0.048	-
Std Dev.			0.0380	0.4572	0.0140	-
Coeff. var			19.30	11.17	29.13	
Min	< 0.1	< 0.02	0.14	3.72	0.03	
Max	< 0.1	< 0.02	0.26	4.99	0.08	
Bergen Bank						
Mean	< 0.1	< 0.02	0.250	3.593	0.036	3.36
Std Dev.			0.0501	0.6778	0.0135	1.5086
Coeff. var.			20.04	18.86	37.50	44.90
Min	< 0.1	< 0.02	0.17	2.50	0.02	1.1
Max	< 0.1	< 0.02	0.31	4.41	0.06	5.7
Ling Bank						
Mean	< 0.1	< 0.02	0.301	4.191	0.049	3.32
Std Dev.			0.0806	1.1209	0.0202	2.0531
Coeff. var.			26.78	26.75	41.32	61.84
Min	< 0.1	< 0.02	0.16	2.02	0.02	1.4
Max	< 0.1	< 0.02	0.40	6.16	0.08	6.7

Haddock (Contd.)

	Pb	Cd	Cu	Zn	Hg	As
Lossiemouth						
Mean	< 0.1	< 0.02	0.250	3.130	0.045	-
Std Dev.			0.0950	0.4764	0.0196	
Coeff. var.			37.99	15.22	43.51	
Min	< 0.1	< 0.02	0.13	2.34	0.02	
Max	< 0.1	< 0.02	0.42	3.59	0.09	
Lerwick						
Mean	< 0.1	< 0.02	0.194	3.561	0.028	1.54
Std Dev.			0.1065	0.5773	0.0063	0.4033
Coeff. var.			54.89	16.21	22.59	26.19
Min	< 0.1	< 0.02	0.12	2.39	0.02	1.1
Max	< 0.1	< 0.02	0.48	4.43	0.04	2.4

Hake

Ayr						
Mean	< 0.1	< 0.02	0.215	3.993	0.032	0.84
Std Dev.			0.0472	0.2774	0.0169	0.3206
Coeff. var.			21.953	6.947	52.81	38.17
Min	< 0.1	< 0.02	0.14	3.65	0.01	0.5
Max	< 0.1	< 0.02	0.27	4.57	0.06	1.5

Halibut

Aberdeen						
Mean	< 0.1	< 0.02	0.226	4.35	0.023	-
Std Dev.			0.0789	0.3521	0.001	
Coeff. var.			34.912	8.094	4.3478	
Min.	< 0.1	< 0.02	0.15	3.99	0.01	
Max	< 0.1	< 0.02	0.41	5.22	0.04	

Herring

Ayr						
Mean	< 0.1	< 0.02	0.535	4.38	0.088	1.41
Std Dev.			0.1237	0.4780	0.0385	0.4909
Coeff. var.			23.121	10.913	43.750	34.816
Min	< 0.1	< 0.02	0.34	3.38	0.03	0.7
Max	< 0.1	< 0.02	0.74	4.89	0.15	2.4
Mallaig						
Mean	< 0.1	< 0.02	0.372	4.847	0.058	0.86
Std Dev.			0.1819	0.7401	0.0161	0.3098
Coeff. var.			48.898	15.269	27.759	36.023
Min	< 0.1	< 0.02	0.17	4.14	0.03	0.5
Max	< 0.1	< 0.02	0.77	6.62	0.08	1.5
Stornoway						
Mean	< 0.1	< 0.02	0.762	4.917	0.023	1.19
Std Dev			0.4518	0.5646	0.0141	0.5110
Coeff. var.			59.291	11.483	61.304	42.941
Min	< 0.1	< 0.02	0.40	4.37	0.01	0.7
Max	< 0.1	< 0.02	1.73	6.11	0.06	2.3

Herring (Contd.)

	Pb	Cd	Cu	Zn	Hg	As
Lossiemouth						
Mean	< 0.1	< 0.02	0.720	7.359	0.019	-
Std Dev.			0.2554	1.5506	0.01101	
Coeff. var			27.924	11.547	65.862	
Min	< 0.1	< 0.02	0.41	4.96	0.01	
Max	< 0.1	< 0.02	0.90	7.33	0.08	
Lerwick						
Mean	< 0.1	< 0.02	0.607	6.204	0.029	0.93
Std Dev.			0.1695	0.7164	0.0191	0.3444
Coeff. var.			27.924	11.547	65.862	37.032
Min	< 0.1	< 0.02	0.41	4.96	0.01	0.4
Max	< 0.1	< 0.02	0.90	7.33	0.08	1.4

Lemon sole

Aberdeen						
Mean	< 0.1	< 0.02	0.180	3.836	0.041	11.49
Std Dev.			0.0437	0.4599	0.016	4.4578
Coeff. var.			24.287	11.989	39.024	38.797
Min	< 0.1	< 0.02	0.13	3.15	0.02	6.8
Max	< 0.1	< 0.02	0.27	4.47	0.06	19.5

Ling

Ullapool						
Mean	< 0.1	< 0.02	0.199	4.79	0.114	-
Std Dev.			0.0969	1.2200	0.0802	
Coeff. var.			48.693	25.470	70.351	
Min	< 0.1	< 0.02	0.11	3.13	0.03	
Max	0.25	< 0.02	0.46	6.89	0.24	
Aberdeen						
Mean	< 0.1	< 0.02	0.208	4.468	0.062	2.40
Std Dev.			0.1131	0.6592	0.0434	0.9018
Coeff. var.			54.383	14.754	70.000	37.575
Min	< 0.1	< 0.02	0.12	3.77	0.02	1.2
Max	< 0.1	< 0.02	0.49	5.18	0.18	3.8

Mackerel

Ayr						
Mean	< 0.1	< 0.02	0.888	5.151	0.093	1.04
Std Dev.			0.4151	1.6185	0.0485	0.3950
Coeff. var.			46.745	31.421	52.151	37.981
Min	< 0.1	< 0.02	0.44	3.41	0.02	0.4
Max	0.41	< 0.02	1.53	8.74	0.18	1.7
Mallaig						
Mean	< 0.1	< 0.02	0.771	3.766	0.054	-
Std Dev.			0.4550	0.7599	0.0196	
Coeff. var.			59.015	20.178	36.296	
Min	< 0.1	< 0.02	0.38	1.93	0.02	
Max	< 0.1	< 0.03	1.84	4.47	0.09	

Mackerel (Contd.)

	Pb	Cd	Cu	Zn	Hg	As
North Coast						
Mean	< 0.1	< 0.02	0.756	4.856	0.031	
Std Dev.			0.3666	1.0306	0.0137	
Coeff. var.			48.486	21.223	44.194	
Min	< 0.1	< 0.02	0.44	3.22	0.01	
Max	< 0.1	< 0.02	1.56	6.82	0.05	
Forth						
Mean	< 0.1	< 0.02	0.551	3.575	0.096	0.42
Std Dev.			0.1342	0.2858	0.0518	0.1751
Coeff.			24.356	7.994	53.958	41.690
Min	< 0.1	< 0.02	0.37	3.00	0.03	0.2
Max	< 0.1	< 0.02	0.80	4.09	0.17	0.7
Aberdeen						
Mean	< 0.1	< 0.02	1.113	5.168	0.092	-
Std Dev.			0.3675	1.4754	0.0355	
Coeff. var.			33.018	28.549	38.587	
Min	< 0.1	< 0.02	0.70	4.10	0.04	
Max	< 0.1	< 0.02	1.81	9.20	0.16	
Lossiemouth						
Mean	< 0.1	< 0.02	0.833	3.983	0.054	-
Std Dev.			0.2957	0.4724	0.0171	
Coeff. var.			35.495	11.860	31.667	
Min	< 0.1	< 0.02	0.60	3.40	0.03	
Max	< 0.1	< 0.02	1.55	4.97	0.09	
Bergen Bank						
Mean	< 0.1	< 0.02	0.653	3.495	0.060	0.98
Std Dev.			0.3919	1.1091	0.0216	0.4193
Coeff. var.			60.015	20.184	36.000	42.786
Min	< 0.1	< 0.02	0.44	4.05	0.03	0.7
Max	< 0.1	< 0.02	1.24	6.56	0.08	1.6
Lerwick						
Mean	< 0.1	< 0.02	0.870	3.971	0.103	0.68
Std Dev.			0.4380	0.5950	0.0271	0.3327
Coeff. var.			50.345	14.983	26.311	48.926
Min	< 0.1	< 0.02	0.54	3.33	0.06	0.3
Max	< 0.1	< 0.02	1.99	5.05	0.15	1.4

Megrim

Ullapool						
Mean	< 0.1	< 0.02	0.141	3.605	0.031	2.21
Std Dev.			0.0545	0.5644	0.0120	0.6488
Coeff. var.			38.622	15.655	38.620	29.357
Min	< 0.1	< 0.02	0.07	2.95	0.02	1.2
Max	< 0.1	< 0.02	0.26	4.64	0.05	3.4

Monkfish

	Pb	Cd	Cu	Zn	Hg	As
Ayr						
Mean	< 0.1	< 0.02	0.259	5;763	0.080	-
Std Dev.			0.043	1.8375	0.0245	
Coeff. var.			17.104	31.884	30.625	
Min	< 0.1	< 0.02	0.21	4.29	0.04	
Max	< 0.1	< 0.02	0.34	10.5	0.12	
Ullapool						
Mean	< 0.1	< 0.02	0.204	4.841	0.081	-
Std Dev.			0.1011	0.8997	0.0352	
Coeff. var.			49.359	18.585	43.457	
Min	< 0.1	< 0.02	0.11	3.59	0.04	
Max	< 0.1	< 0.02	0.40	6.35	0.16	
Faroe						
Mean	< 0.1	< 0.02	0.231	4.732	0.096	-
Std Dev.			0.1093	1.3144	0.0588	
Coeff. var.			47.316	27.777	61.250	
Min	<0.01	< 0.02	0.12	3.29	0.02	
Max	< 0.1	< 0.02	0.44	7.70	0.21	
Aberdeen						
Mean	< 0.1	< 0.02	0.142	4.352	0.009	-
Std Dev.			0.0498	0.4165	0.0470	
Coeff. var.			35.070	9.570	47.475	
Min	< 0.1	< 0.02	0.08	3.76	0.04	
Max	< 0.1	< 0.02	0.25	5.00	0.20	
Aberdeen Bank						
Mean	< 0.1	< 0.02	0.181	4.738	0.083	
Std Dev.			0.0410	1.0369	0.0352	
Coeff. var.			22.652	21.884	42.410	
Min	< 0.1	< 0.02	0.12	3.28	0.03	
Max	< 0.1	< 0.02	0.26	7.46	0.16	
Lossiemouth						
Mean	< 0.1	< 0.02	0.237	5.449	0.055	
Std Dev.			0.1157	1.9030	0.0295	
Coeff. var.			48.819	34.924	53.636	
Min	< 0.1	< 0.02	0.10	1.59	0.01	
Max	< 0.1	< 0.02	0.53	7.89	0.12	
Lerwick						
Mean	< 0.1	< 0.02	0.220	5.252	0.080	7.36
Std Dev.			0.1107	0.9531	0.0313	4.3664
Coeff. var.			50.318	18.147	39.125	59.326
Min	< 0.1	< 0.02	0.14	4.34	0.05	3.7
Max	< 0.1	< 0.02	0.44	7.70	0.16	17.5

Plaice

Ayr						
Mean	< 0.1	< 0.02	0.259	5.186	0.057	9.07
Std Dev.			0.1451	0.8557	0.0411	3.0826
Coeff. var.			56.024	16.500	72.12	33.987
Min	< 0.1	< 0.02	0.13	4.12	0.02	5.6
Max	< 0.1	< 0.02	0.64	6.37	0.15	14.4

Plaice (Contd.)

	Pb	Cd	Cu	Zn	Hg	As
Forth						
Mean	< 0.1	< 0.02	0.332	4.903	0.059	3.95
Std Dev.			0.0902	0.3226	0.0253	1.8241
Coeff. var.			27.157	6.580	42.91	46.18
Min	< 0.1	< 0.02	0.22	4.42	0.03	1.0
Max	< 0.1	< 0.02	0.48	5.38	0.09	4.9
Aberdeen						
Mean	< 0.1	< 0.02	0.181	4.446	0.063	7.25
Std Dev.			0.0242	0.6434	0.0295	2.6129
Coeff. var.			13.394	14.473	46.76	36.04
Min	< 0.1	< 0.02	0.17	3.00	0.03	4.0
Max	< 0.1	< 0.02	0.24	5.21	0.12	11.2
Bergen Bank						
Mean	< 0.1	< 0.02	0.237	4.624	0.062	15.05
Std Dev.			0.1444	0.8279	0.0294	6.3990
Coeff. var.			60.920	17.904	47.36	42.518
Min	< 0.1	< 0.02	0.10	3.24	0.04	6.7
Max	< 0.1	< 0.02	0.53	5.98	0.11	27.5
Ling Bank						
Mean	< 0.1	< 0.02	0.203	4.362	0.084	43.22
Std Dev.			0.0675	0.7769	0.0448	25.253
Coeff. var.			33.25	17.81	53.30	58.429
Min	< 0.1	< 0.02	0.14	3.55	0.05	9.5
Max	< 0.1	< 0.02	0.38	5.36	0.19	89.9
Lossiemouth						
Mean	< 0.1	< 0.02	0.224	4.302	0.029	15.09
Std Dev.			0.0640	0.3404	0.0145	11.221
Coeff. var.			28.562	7.912	49.97	74.361
Min	< 0.1	< 0.02	0.14	3.74	0.01	3.3
Max	< 0.1	< 0.02	0.35	4.70	0.06	31.3
Lerwick						
Mean	< 0.1	< 0.02	0.122	5.150	0.016	2.47
Std Dev.			0.0525	0.2813	0.0052	0.5078
Coeff. var.			42.993	5.461	32.27	20.559
Min	< 0.1	< 0.02	0.02	4.68	0.01	1.5
Max	0.83	< 0.02	0.18	5.63	0.02	3.1

Saithe

Ayr						
Mean	< 0.1	< 0.02	0,411	4.727	0.100	0.97
Std Dev.			0.1234	0.7641	0.0333	0.3466
Coeff. var.			30.029	16.165	33.300	35.732
Min	< 0.1	< 0.02	0.22	3.35	0.06	0.7
Max	< 0.1	< 0.02	0.65	5.97	0.16	1.7

Saithe (Contd.)

	Pb	Cd	Cu	Zn	Hg	As
Forth						
Mean	< 0.1	< 0.02	0.296	3.334	0.081	0.64
Std Dev.			0.1211	1.1598	0.0213	0.1265
Coeff. var.			40.920	34.788	26.318	19.766
Min	< 0.1	< 0.02	0.13	1.55	0.04	0.4
Max	< 0.1	< 0.02	0.54	5.08	0.11	0.8
Aberdeen						
Mean	< 0.1	< 0.02	0.524	5.876	0.032	-
Std Dev.			0.2659	1.3109	0.0078	
Coeff. var.			50.741	22.309	24.375	
Min	< 0.1	< 0.02	0.28	4.82	0.02	
Max	< 0.1	< 0.02	1.03	9.33	0.04	
Bergen Bank						
Mean	< 0.1	< 0.02	0.336	3.715	0.090	0.92
Std Dev.			0.1421	0.4133	0.0505	0.4872
Coeff. var.			42.281	11.125	56.111	52.957
Min	< 0.1	< 0.02	0.22	3.21	0.03	0.2
Max	< 0.1	< 0.03	0.61	4.43	0.18	1.8
Ling Bank						
Mean	< 0.1	< 0.02	0.480	5.039	0.090	1.44
Std Dev.			0.2314	0.5744	0.0385	0.8195
Coeff. var.			48.213	11.399	42.778	56.910
Min	< 0.1	< 0.02	0.27	3.95	0.03	0.5
Max	< 0.1	< 0.02	1.02	5.62	0.14	3.5
Lossiemouth						
Mean	< 0.1	< 0.02	0.340	4.742	0.043	-
Std Dev.			0.1529	0.5588	0.0125	
Coeff. var.			44.971	11.784	29.070	
Min	< 0.1	< 0.02	0.20	3.94	0.03	
Max	< 0.1	< 0.02	0.66	5.83	0.07	
Lerwick						
Mean	< 0.1	< 0.02	0.300	5.619	0.037	0.59
Std Dev.			0.0945	0.5952	0.0278	0.2234
Coeff. var.			31.500	10.593	75.135	39.559
Min	< 0.1	< 0.02	0.21	4.70	0.02	0.4
Max	0.4	< 0.02	0.54	6.40	0.11	1.0

Skate

Aberdeen						
Meanq	< 0.1	< 0.02	0.353	5.306	0.054	15.39
Std Dev.			0.1522	0.8572	0.0291	8.1389
Coeff. var.			43.129	16.155	53.889	52.884
Min	< 0.1	< 0.02	0.17	3.95	0.02	7.7
Max	< 0.1	< 0.02	0.52	7.07	0.11	31.8

Sprat

	Pb	Cd	Cu	Zn	Hg	As
Ayr						
Mean	< 0.1	< 0.02	0.683	6.09	0.037	1.48
Std Dev.			0.1734	2.6266	0.0254	0.3938
Coeff. var.			25.388	43.130	68.649	26.608
Min	< 0.1	< 0.02	0.38	2.88	0.01	0.8
Max	< 0.1	< 0.02	1.03	9.35	0.08	2.2
Forth						
Mean	< 0.1	0.29	0.817	10.005	0.043	1.83
Std Dev.		0.0057	0.1218	2.5581	0.0162	0.3830
Coeff. var.		19.665	14.908	25.838	37.674	20.929
Min	< 0.1	0.02	0.69	6.73	0.01	1.2
Max	< 0.1	0.04	1.05	15.9	0.06	2.3
Lossiemouth						
Mean	< 0.1	0.060	0.739	10.07	0.023	-
Std Dev.		0.0406	0.0817	1.5585	0.0079	
Coeff. var.		67.667	11.055	15.477	34.348	
Min	< 0.1	0.02	0.73	8.04	< 0.01	
Max	< 0.1	0.17	0.86	13.2	0.03	

Squid

Ayr						
Mean	0.26	0.19	1.925	13.40	0.060	8.03
Std Dev.			0.4349	1.0360	0.0428	2.419
Coeff. var.			22.592	7.731	71.333	30.125
Min	< 0.1	< 0.02	1.50	12.4	0.01	5.3
Max	0.4	0.7	2.50	14.8	044	9 9
Mallaig						
Mean	< 0.1	< 0.02	1.908	14.3	0.043	5.87
Std Dev.			0.2761	1.4166	0.0189	1.665
Coeff. var.			14.471	9.906	43.953	28.364
Min	< 0.1	< 0.02	1.70	12.8	0.03	4.0
Max	< 0.1	< 0.02	2.30	14.3	0.07	7.2
Ling Bank						
Mean	-	-	-	-	0.033	3.85
Std Dev.	-	-	-	-	0.005	0.656
Coeff. var.	-	-	-	-	15.152	17.039
Min	-	-	-	-	0.03	3.3
Max	-	-	-	-	0.04	4.8

Whiting

Ayr						
Mean	< 0.1	< 0.02	0.189	4.010	0.049	1.40
Std Dev.			0.1056	0.6696	0.0251	0.5538
Coeff. var.			55.85	16.70	51.31	39.557
Min	< 0.1	< 0.02	0.02	3.23	0.02	0.9
Max	0.42	< 0.02	0.38	5.15	0.11	2.4

Whiting (Contd.)

	Pb	Cd	Cu	Zn	Hg	As
Forth						
Mean	< 0.1	< 0.02	0.299	4.713	0.087	1.48
Std Dev.			0.0477	0.8311	0.0492	0.4566
Coeff. var.			15.96	17.63	56.58	30.851
Min	< 0.1	< 0.02	0.24	4.06	0.03	1.0
Max	< 0.1	< 0.02	0.38	6.90	0.21	2.5
Ayr						
Mean	< 0.1	< 0.02	0.216	4.297	0.061	-
Std Dev.			0.0366	0.5478	0.0398	
Coeff. var.			16.93	12.75	65.32	
Min	< 0.1	< 0.02	0.16	3.59	0.02	
Max	< 0.1	< 0.02	0.29	4.98	0.13	
Bergen Bank						
Mean	< 0.1	< 0.02	0.246	3.712	0.045	1.73
Std Dev.			0.1189	0.4029	0.0178	0.5618
Coeff. var.			48.33	10.85	39.54	32.474
Min	< 0.1	< 0.02	0.14	3.19	0.02	0.8
Max	< 0.1	< 0.02	0.55	4.38	0.08	2.6
Ling Bank						
Mean	< 0.1	< 0.02	0.185	3.935	0.044	1.53
Std Dev.			0.0401	0.5202	0.0143	0.5458
Coeff. var.			21.66	13.22	32.50	35.673
Min	< 0.1	< 0.02	1.12	3.05	0.03	0.8
Max	< 0.1	< 0.02	0.26	5.08	0.07	2.8
Lossiemouth						
Mean	< 0.1	< 0.02	0.203	3.897	0.052	-
Std Dev.			0.0445	0.5953	0.0181	
Coeff. var.			21.91	15.28	34.88	
Min	< 0.1	< 0.02	0.15	2.87	0.03	
Max	< 0.1	< 0.02	0.25	4.94	0.09	
Lerwick						
Mean	< 0.1	< 0.02	0.172	4.188	0.031	0.97
Std Dev.			0.0509	0.6145	0.0120	0.3433
Coeff. var.			29.62	14.67	38.62	35.392
Min	< 0.1	< 0.02	0.12	3.52	0.02	0.7
Max	0.18	< 0.02	0.30	5.13	0.05	1.8

Witch

Ayr						
Mean	< 0.1	< 0.02	0.119	3.742	0.088	15.6
Std Dev.			0.0477	1.0707	0.0326	7.2792
Coeff. var.			40.096	28.613	37.045	46.662
Min	< 0.1	< 0.02	0.03	3.10	0.03	2.5
Max	0.49	< 0.02	0.20	6.52	0.13	24.5

Witch (Contd.)

	Pb	Cd	Cu	Zn	Hg	As
Bergen Bank						
Mean	< 0.1	< 0.02	0.137	3.094	0.185	14.76
Std Dev.			0.0298	0.6034	0.1800	7.0086
Coeff. var.			21.776	19.504	97.297	47.484
Min	< 0.1	< 0.02	0.09	1.92	0.03	6.8
Max	< 0.1	< 0.02	0.16	3.64	0.65	28.2
Ling Bank						
Mean	0.1	< 0.02	0.184	3.161	0.090	12.72
Std Dev.			0.1144	0.5404	0.0400	11.7809
Coeff. var.			62.174	17.096	44.444	92.617
Min	< 0.1	< 0.02	0.11	2.60	0.04	4.6
Max	0.3	< 0.02	0.38	4.13	0.16	44.2

Table V Summary of concentrations of metals (μg g $^{-1}$ wet weight) in shellfish landed at Scottish ports

Crab

	Pb	Cd	Cu	Zn	Hg	As
Kirkwall (West coast of Orkney)						
Claw						
Mean	0.18	< 0.02	7.10	91.21	0.127	7.57
Std Dev.			0.940	12.42	0.031	2.887
Coeff. var.			13.239	13.617	24.409	38.134
Min	< 0.1	< 0.02	6.06	76.88	0.10	5.9
Max	< 0.3	< 0.02	7.89	98.75	0.16	10.9
Body						
Mean	0.30	1.13	11.87	41.14	0.12	11.57
Std Dev.	0.170	0.789	6.49	30.13	0.0529	9.646
Coeff. var.	56.667	69.823	54.676	73.238	44.083	83.371
Min	0.1	0.64	5.05	23.42	0.06	5.7
Max	0.4	2.04	17.96	75.93	0.16	22.7
Stromness						
Claw						
Mean	< 0.1	0.10	8.851	92.12	0.089	12.74
Std Dev.			4.781	22.362	0.052	7.6586
Coeff. var.			54.016	24.275	58.427	60.115
Min	< 0.1	< 0.02	2.33	35.6	0.03	4.5
Max	0.35	0.44	18.65	123.8	0.23	28.9
Body						
Mean	< 0.1	117.16	34.73	49.79	0.077	9.70
Std Dev.		18.96	38.50	20.46	0.076	6.0187
Coeff. var.		110.490	110.55	41.093	98.701	62.048
Min	< 0.1	1.93	4.87	24.0	0.02	3.3
Max	0.74	62.00	153.00	83.2	0.30	27.6
Eyemouth						
Claw						
Mean	< 0.1	< 0.02	24.13	68.09	0.160	23.29
Std Dev.			23.19	21.37	0.061	10.494
Coeff. var.			96.104	31.385	38.125	45.060
Min	< 0.1	< 0.02	12.18	24.30	0.09	8.0
Max	0.4	0.05	89.30	100.21	0.28	38.2
Body						
Mean	< 0.1	5.28	52.70	47.04	0.113	17.40
Std Dev.		4.400	21.882	44.94	0.041	6.495
Coeff. var.		83.333	41.522	95.536	36.283	37.326
Min	< 0.1	0.63	32.60	20.14	0.06	7.9
Max	0.5	13.12	108.32	170.2	0.19	28.3

Processed Crab

	Pb	Cd	Cu	Zn	Hg	As
Orkney						
White meat						
Mean	< 0.1	0.083	21.58	110.94	0.103	12.2
Std Dev.			18.223	10.148	0.0289	
Coeff. var.			84.444	9.147	28.027	
Min	< 0.1	0.08	9.49	99.61	0.07	
Max	< 0.1	0.09	42.54	119.2	0.12	
Brown meat						
Mean	< 0.1	9.083	14.163	54.543	0.080	6.6
Std Dev.		6.209	5.507	21.874	0.010	
Coeff. var.		68.362	38.881	40.103	0,125	
Min	< 0.1	4.50	8.82	41.74	0.07	
Max	< 0.1	16.15	19.82	79.8	0.09	
Kirkwall (West Orkney)						
Claw						
Mean	< 0.1	0.103	21.293	41.390	0.085	6.93
Std Dev.			5.353	10.017	0.0551	3.0709
Coeff. var.			25.139	24.201	64.795	44.357
Min	< 0.1	< 0.02	15.39	26.90	0.03	4.5
Max	< 0.1	0.3	28.34	49.44	0.15	11.0
Tail						
Mean	< 0.1	0.053	5.460	17.058	0.144	7.56
Std Dev.			1.651	0.779	0.071	5.8977
Coeff. var.			30.236	4.566	49.252	78.012
Min	< 0.1	< 0.02	3.84	16.22	0.07	3.9
Max	< 0.1	0.06	7.55	17.99	0.26	17.9
Stromness (Scapa Flow)						
Claw						
Meanq	< 0.1	0.024	23.036	25.512	0.038	4.60
Std Dev.			5.446	9.229	0.0249	0.9566
Coeff. var.			23.640	36.174	65.526	20.794
Min	< 0.1	< 0.02	16.23	17.81	0.02	3.3
Max	< 0.1	< 0.04	30.16	37.77	0.08	5.7
Tail						
Mean	0.19	< 0.02	4.998	15.324	0.142	5.28
Std Dev.			1.150	0.5199	0.0712	0.8585
Coeff. var.			23.012	3.393	50.144	16.259
Min	< 0.1	< 0.02	3.79	14.48	0.08	4.6
Max	0.4	0.02	6.31	15.81	0.25	6.7

Norway lobster

	Pb	Cd	Cu	Zn	Hg	As
Ayr						
Homogenate of 50	< 0.1	< 0.02	3.17	12.14	0.13	2.6
South Minch						
Mean	< 0.1	0.159	7.174	16.45	0.067	-
Std Dev.		0.0764	4.284	2.681	0.02359	
Coeff. var.		48.067	59.712	16.296	35.209	
Min	< 0.1	0.08	1.94	13.6	0.03	
Max	< 0.1	0.29	12.0	20.7	0.10	
North Minch						
Mean	< 0.1	0.07	3.76	14.0	0.088	-
Std Dev.					0.0537	
Coeff. var.					61.0307	
Min	< 0.1	0.05	1.85	12.5	0.04	
Max	< 0.1	0.09	5.67	15.5	0.22	
Forth						
Homogenate of 50	< 0.1	< 0.02	4.89	13.5	0.06	2.7

Periwinkle

Ayr						
Homogenate of 50	< 0.1	0.15	14.75	18.5	0.01	-
Forth						
Homogenate of 50	< 0.1	0.21	15.97	13.44	0.05	-

Queen

Ayr						
Mean	0.95	0.281	3.56	84.18	0.024	0.925
Std Dev.	0.72	0.082	2.682	93.43	0.023	0.2605
Coeff. var.	75.789	29.181	75.337	110.99	95.833	28.162
Min	0.2	0.16	0.99	21.5	0.01	0.4
Max	2.4	0.43	9.07	302.0	0.08	1.2

Scallop

Ayr						
Muscle						
Mean	0.314	0.833	0.551	36.86	0.011	0.96
Std Dev.		0.250	0.241	14.06	0.0032	0.1174
Coeff. var.		30.012	43.739	38.144	29.091	12.227
Min	< 0.1	0.57	0.24	17.0	0.01	0.8
Max	0.67	1.44	0.96	59.0	0.02	1.2

Scallop (Contd.)

	Pb	Cd	Cu	Zn	Hg	As
Gonad						
Mean	0.15	2.71	6.714	95.11	0.017	-
Std Dev.		3.519	4.182	83.92	0.014	
Coeff. var.		129.85	62.288	88.235	82.353	
Min	< 0.1	0.65	2.39	40.0	0.01	
Max	0.6	10.57	13.16	280.0	0.05	
Lerwick						
Muscle						
Mean	0.2	0.440	0.494	17.11	0.020	1.45
Std Dev.		0.224	0.267	10.84	0.0155	0.3611
Coeff. var.		50.909	54.049	63.355	77.50	24.903
Min	< 0.1	0.19	0.27	11.3	0.01	0.8
Max	1.5	0.84	1.09	54.8	0.06	2.1
Gonad						
Mean	0.23	0.729	2.941	49.54	0.031	-
Std Dev.		0.375	1.243	10.76	0.0263	
Coeff. var.		51.440	42.265	21.720	84.839	
Min	< 0.1	0.39	1.52	37.8	0.01	
Max	2.5	1.54	6.06	77.3	0.10	

Shrimp

Farne Deeps						
Mean	0.47	0.045	5.7	15.5	0.085	

Table VI(A) Mean (and median) concentrations of copper in fish landed at Scottish ports ($\mu g\ g^{-1}$ wet weight)

	Clyde	Minches and N.Coast	Faroe	Shetland	Moray Firth	Bergen Bank	Ling Bank	Aberdeen	Forth	Overall
Cod	0.22(0.21)			0.17(0.17)	0.20(0.21)	0.23(0.23)	0.29(0.29)	0.24(0.24)	0.35(0.30)	0.24(0.23)
Dab								0.19(0.17)		0.18(0.17)
Dogfish								0.62(0.52)		0.62(0.52)
Haddock	0.18(0.18)			0.19(0.17)	0.25(0.23)	0.25(0.27)	0.30(0.33)	0.20(0.19)	0.30(0.29)	0.24(0.23)
Hake	0.22(0.23)									0.22(0.23)
Halibut								0.23(0.20)		0.23(0.20)
Herring	0.54(0.52)	0.57(0.47)		0.61(0.58)	0.72(0.45)					0.61(0.52)
Lemon Sole								0.18(0.12)		0.18(0.17)
Ling		0.20(0.17)						0.21(0.18)		0.20(0.17)
Mackerel	0.89(0.79)	0.76(0.67)		0.87(0.69)	0.82(0.78)	0.65(0.47)		1.11(0.99)	0.55(0.56)	0.81(0.69)
Megrim		0.14(0.13)								0.14(0.13)
Monkfish	0.26(0.24)	0.20(0.20)	0.231(0.18)	0.22(0.18)	0.24(0.22)			0.16(0.17)		0.22(0.18)
Plaice	0.26(0.22)			0.12(0.14)	0.23(0.24)	0.24(0.19)	0.20(0.20)	0.18(0.18)	0.33(0.36)	0.22(0.20)
Saithe	0.41(0.44)			0.30(0.28)	0.34(0.31)	0.34(0.30)	0.48(0.43)	0.54(0.48)	0.30(0.29)	0.38(0.31)
Skate								0.35(0.34)		0.35(0.34)
Sprat	0.68(0.68)				0.74(0.73)				0.82(0.83)	0.75(0.73)
Squid	1.93(2.00)	1.91(1.90)								1.92(1.90)
Whiting	0.19(0.19)			0.17(0.17)	0.20(0.21)	0.25(0.23)	0.19(0.19)	0.22(0.21)	0.30(0.31)	0.22(0.21)
Witch	0.12(0.13)					0.19(0.14)	0.18(0.13)			0.16(0.13)

Table VI(B) Mean (and median) concentrations of zinc in fish landed at Scottish ports ($\mu g\ g^{-1}$ wet weight)

	Clyde	Minches and N.Coast	Faroe	Shetland	Moray Firth	Bergan Bank	Ling Bank	Aberdeen	Forth	Overall
Cod	3.84(3.89)			3.92(4.05)	4.36(4.67)	3.96(3.99)	4.43(4.61)	4.45(4.47)	4.50(4.48)	4.21(4.47)
Dab								5.25(5.12)		5.25(5.12)
Dogfish								4.75(4.65)		4.75(4.65)
Haddock	3.31(3.35)			3.56(3.60)	3.13(3.30)	3.59(3.87)	4.19(4.30)	4.09(3.93)	4.45(4.52)	3.76(3.87)
Hake	3.99(3.97)									3.99(3.97)
Halibut								4.35(4.30)		4.35(4.30)
Herring	4.38(4.29)	4.88(4.82)		6.20(6.33)	7.36(7.36)					5.71(4.82)
Lemon Sole								3.84(4.08)		3.84(4.08)
Ling		4.79(4.24)						4.47(4.39)		4.63(4.24)
Mackerel	5.15(4.79)	4.32(4.46)		3.97(3.80)	3.98(3.96)	5.50(6.13)		5.17(4.74)	3.58(3.61)	4.52(4.46)
Megrim		3.61(3.51)								3.61(3.51)
Monkfish	5.76(5.18)	4.84(4.62)	4.73(4.65)	5.25(5.23)	5.45(5.90)			4.54(4.60)		5.10(4.65)
Plaice	5.19(5.56)			5.15(5.16)	4.30(4.31)	4.62(4.65)	4.36(4.54)	4.45(4.38)	4.90(4.97)	4.71(4.65)
Saithe	4.73(4.82)			5.62(5.85)	4.74(4.83)	3.72(3.76)	5.03(5.11)	5.88(5.45)	3.34(3.64)	4.72(4.83)
Skate								5.31(5.47)		5.31(5.47)
Sprat	6.09(7.36)				10.07(9.72)				10.01(9.70)	8.72(9.70)
Squid	13.40(13.5)	14.30(14.3)								13.85(13.5)
Whiting	4.01(4.12)			4.19(3.92)	3.90(3.82)	3.71(3.76)	3.94(3.97)	4.30(4.53)	4.71(4.63)	4.11(3.87)
Witch	3.74(3.38)					3.09(3.19)	3.16(2.91)			3.33(3.19)

Table VI(C) Mean (and median) concentrations of mercury in fish landed at Scottish ports ($\mu g\ g^{-1}$ wet weight)

	Clyde	Minches and N.Coast	Faroe	Shetland	Moray Firth	Bergen Bank	Ling Bank	Aberdeen	Forth	Overall
Cod	0.08(0.08)			0.02(0.03)	0.04(0.04)	0.04(0.04)	0.05(0.06)	0.11(0.09)	0.16(0.15)	0.07(0.06)
Dab								0.10(0.08)		0.10(0.08)
Dogfish								0.10(0.10)		0.10(0.10)
Haddock	0.04(0.03)			0.03(0.03)	0.05(0.04)	0.04(0.03)	0.05(0.06)	0.05(0.05)	0.05(0.05)	0.04(0.04)
Hake	0.03(0.03)									0.03(0.03)
Halibut								0.02(0.02)		0.02(0.02)
Herring	0.09(0.10)	0.04(0.04)		0.03(0.03)	0.02(0.02)					0.04(0.03)
Lemon sole								0.04(0.04)		0.04(0.04)
Ling		0.11(0.11)						0.06(0.06)		0.09(0.06)
Mackerel	0.09(0.10)	0.04(0.05)		0.10(0.10)	0.05(0.05)	0.06(0.07)		0.09(0.10)	0.10(0.08)	0.08(0.08)
Megrim		0.03(0.03)								0.03(0.03)
Monkfish	0.08(0.08)	0.08(0.07)	0.10(0.09)	0.08(0.08)	0.06(0.05)			0.09(0.09)		0.08(0.08)
Plaice	0.06(0.04)			0.02(0.02)	0.03(0.03)	0.06(0.04)	0.08(0.07)	0.06(0.06)	0.06(0.05)	0.05(0.04)
Saithe	0.10(0.09)			0.04(0.03)	0.04(0.04)	0.09(0.08)	0.09(0.11)	0.03(0.03)	0.08(0.09)	0.07(0.08)
Skate								0.05(0.05)		0.05(0.05)
Sprat	0.04(0.03)				0.02(0.02)				0.04(0.05)	0.03(0.03)
Squid	0.06(0.09)	0.04(0.04)					0.03(0.03)			0.05(0.04)
Whiting	0.05(0.05)			0.03(0.03)	0.05(0.05)	0.05(0.05)	0.04(0.05)	0.06(0.05)	0.09(0.08)	0.05(0.05)
Witch	0.09(0.10)					0.19(0.14)	0.09(0.09)			0.12(0.10)

Table VI(D) Mean (and median) concentrations of arsenic in fish landed at Scottish ports ($\mu g\ g^{-1}$ wet weight)

	Clyde	Minches and N.Coast	Faroe	Shetland	Moray Firth	Bergen Bank	Ling Bank	Aberdeen	Forth	Overall
Cod	4.6(3.9)			0.7(0.6)		1.4(1.5)	1.6(1.3)		2.1(2.0)	2.1(1.5)
Dab								4.5(3.9)		4.5(3.9)
Dogfish								2.7(2.7)		2.7(2.7)
Haddock				1.5(1.4)		3.4(3.4)	3.3(2.7)		3.0(3.0)	2.8(2.7)
Hake	0.8(0.8)									0.8(0.8)
Halibut										
Herring	1.5(1.5)	1.0(0.9)		0.9(1.0)						1.1(1.0)
Lemon sole								11.5(10.5)		11.5(10.5)
Ling								2.4(2.4)		2.4(2.4)
Mackerel	1.0(1.1)			0.7(0.6)		1.0(0.8)			0.4(0.4)	0.8(0.6)
Megrim		2.2(2.1)								2.2(2.1)
Monkfish				7.4(6.6)						7.4(6.6)
Plaice	9.1(8.6)			2.5(2.5)	15.1(14.6)	15.0(14.6)	43.2(44.9)	7.3(7.2)	3.9(4.4)	13.7(8.6)
Saithe	1.0(0.9)			0.6(0.5)		0.9(0.8)	1.4(1.3)		0.6(0.7)	0.9(0.8)
Skate								15.4(13.6)		15.4(13.6)
Sprat	1.5(1.6)								1.8(2.0)	1.6(1.6)
Squid	8.0(8.9)	5.9(6.4)					3.9(3.7)			7.0(6.4)
Whiting	1.4(1.2)			1.0(0.9)		1.7(2.1)	1.5(1.6)		1.5(1.3)	1.4(1.3)
Witch	15.6(19.5)					14.8(12.4)	14.8(9.3)			14.4(12.4)

Table VI(E) Mean (and median) concentrations of cadmium in shellfish landed at Scottish ports ($\mu g\ g^{-1}$ wet weight)

		Clyde	Minches	Orkney	Shetland	Forth	Farne Deeps
Crab	— Claw			0.09(0.05)		0.02(0.17)	
	— Body			14.48(7.77)		5.28(0.10)	
	— White			0.08(0.08)			
	— Brown			9.08(6.60)			
Lobster	— Claw			0.06(0.04)			
	— Tail			0.02(0.02)			
Norway lobster		0.02	0.14(0.07)			0.02	
Periwinkle		0.15				0.21	
Queen		0.28(0.31)					
Scallop	— muscle	0.83(0.81)			0.44(0.35)		
	— gonad	2.71(1.60)			0.73(0.58)		
Shrimp							0.05

Table VI(F) Mean (and Median) concentrations of copper in shellfish landed at Scottish ports ($\mu g\ g^{-1}$ wet weight)

		Clyde	Minches	Orkney	Shetland	Forth	Farne Deeps
Crab	— Claw			8.57(7.89)		24.13(18.47)	
	— Body			30.92(17.96)		52.70(48.32)	
	— White			21.58(12.71)			
	— Brown			14.16(13.85)			
Lobster	— Claw			21.15(21.35)			
	— Tail			5.23(5.14)			
Norway lobster		3.17(3.18)	6.59(5.67)			4.89	
Periwinkle		14.75(0.54)				15.97	
Queen		3.56(6.40)					
Scallop	— muscle	0.55			0.49(0.38)		
	— gonad	6.71			2.94(2.62)		
Shrimp							5.7

Table VI(G) Mean (and median) concentrations of zinc in shellfish landed at Scottish ports ($\mu g\ g^{-1}$ wet weight)

		Clyde	Minches	Orkney	Shetland	Forth	Farne Deeps
Crab	— Claw			91.98(93.6)		68.09(64.48)	
	— Body			48.38(41.67)		47.04(38.38)	
	— White			110.9 (114.0)			
	— Brown			54.54(42.09)			
Lobster	— Claw			32.57(33.07)			
	— Tail			16.19(16.22)			
Norway lobster		12.14	15.96(15.5)			13.5	
Periwinkle		18.5				13.44	
Queen		84.2 (43.8)					
Scallop	— muscle	36.9 (36.1)			17.1(15.5)		
	— gonad	95.1 (66.0)			49.5(48.8)		15.5
Shrimp							

Table VI(H) Mean (and median) concentrations of mercury in shellfish landed at Scottish ports ($\mu g\ g^{-1}$ wet weight)

		Clyde	Minches	Orkney	Shetland	Forth	Farne Deeps
Crab	— Claw			0.10(0.09)		0.16(0.17)	
	— Body			0.08(0.06)		0.11(0.10)	
	— White			0.10(0.12)			
	— Brown			0.08(0.08)			
Lobster	— Claw			0.06(0.04)			
	— Tail			0.14(0.14)			
Norway lobster		0.13	0.08(0.07)			0.06	
Periwinkle		0.01				0.05	
Queen		0.02(0.02)					
Scallop	— muscle	0.01(0.01)			0.02(0.01)		
	— gonad	0.02(0.01)			0.03(0.03)		
Shrimp							0.09

Table VI(I) Mean (and median) concentrations of arsenic in shellfish landed at Scottish ports ($\mu g\ g^{-1}$ wet weight)

		Clyde	Minches	Orkney	Shetland	Forth	Farne Deeps
Crab	— Claw			11.9(8.8)		23.3(23.3)	
	— Body			10.08(7.7)		17.4(17.0)	
	— White			12.2			
	— Brown			6.6			
Lobster	— Claw			5.6(4.8)			
	— Tail			6.5(5.2)			
Norway lobster		2.6	5.8			2.7	
Periwinkle							
Queen		0.9(1.0)					
Scallop	— muscle	1.0			1.5(1.3)		
	— gonad						
Shrimp							11.4

Table VII Comparison of mean metal concentrations ($\mu g\ g^{-1}$ wet weight) in fish landed at English, Welsh and Scottish ports

Mercury

	*Grimsby	*Lowestoft	*Plymouth	*Newlyn	*Milford Haven	**Overall	***Scotland
Cod	0.04	0.08	0.13	0.15	0.12	0.10	0.07
Plaice	0.09	0.10	0.10	0.13	0.08	0.10	0.05
Whiting	0.12	0.11	0.19	0.12	0.19	0.14	0.05
Herring	0.09	0.06	0.21		0.10	0.08	0.04
Mackerel	0.09		0.07		0.05	0.07	0.08

Copper

	Grimsby	Lowestoft	Plymouth	Newlyn	Milford Haven	Overall	Scotland
Cod	0.5	0.5	0.3	0.5	0.2	0.4	0.24
Plaice	0.3	0.5	0.5	0.5	0.5	0.4	0.22
Whiting	0.4	0.6	0.7	0.6	0.5	0.6	0.22
Herring	2.1	1.3	1.3		1.1	1.4	0.61
Mackerel	0.7		1.1		1.2	1.0	0.81

Zinc

	Grimsby	Lowestoft	Plymouth	Newlyn	Milford Haven	Overall	Scotland
Cod	3.9	3.0	1.8	3.4	3.3	3.1	4.21
Plaice	4.8	3.6	3.6	4.1	4.4	4.1	4.71
Whiting	4.2	3.0	2.8	3.5	3.3	3.2	4.11
Herring	9.2	4.8	6.1		7.4	7.1	5.71
Mackerel	5.5		5.4		6.1	5.7	4.52

* Data from Murray (1979), for samples collected in 1974
** Mean for England and Wales
*** Data from this report

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